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MASS ACTION IN CEREBRAL FUNCTION[1]

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INTRODUCTION

IN the field of neurophysiology no fact is more firmly established than the functional differentiation of various parts of the cerebral cortex. We are removed from Flourens by nearly 75 years of intensive anatomical research which has settled beyond question the histological diversity of the cortical fields and of their connections with subcortical nuclei. A wealth of physiological and clinical evidence accords with the anatomical findings and proves the association of at least the majority of the cortical fields with special functions. No one to-day can seriously believe that the different parts of the cerebral cortex all have the same functions or can entertain for a moment the proposition of Hermann that because the mind is a unit the brain must also act as a unit.

Yet the problems of localization and of cerebral physiology are far from solved by the demonstration of the anatomical diversity of the cortical fields and of consistent symptoms following the destruction of each. From the practical view of diagnosis there are still problems of the fineness of localization, of the types of functions which are localizable, of the significance of individual variations, and the so-called negative cases.

Symptoms involving purely sensory or motor defects have the most certain diagnostic value: a monoplegia or a limited zone of cutaneous anesthesia are surely indicative of a focal lesion whose position may sometimes be predicted within a few centimeters. But a defect of color vision, a disability in reading, an

[1] Lecture delivered before the Harvey Society, New York, November 20, 1930.

apraxia, or a syntactical aphasia are indicative only of disturbance somewhere within a rather widely extended field, while a simple defect of judgment or change in personality, even when of unquestionable organic origin, can not now be associated with any cerebral locus.

Except in a few instances, it is impossible to predict with any certainty from the locus or severity of a lesion what will be the course of recovery or of deterioration. Until we know more of the nature of depression, diaschisis and the factors of spontaneous recovery, until we know the limitations of reeducation and of vicarious functioning, therapeutic methods must be somewhat uncertain.

From the standpoint of an adequate cerebral physiology also, the classical concept of cerebral localization is of limited value, because of its static character and its failure to provide any answer to the question of how the specialized parts of the cortex interact to produce the integration evident in thought and behavior. The problem here is one of the dynamic relations of the diverse parts of the cortex, whether they be cells or cortical fields. The diversification of parts is a fact of fundamental importance, but it is only one of many which must be discovered before we can form any adequate conception of cerebral organization.

There is a very close relation between the problems of cerebral physiology and of psychology and each science must be broad enough to accommodate itself to the facts revealed by the other. We must agree with Henschen that *a priori* psychological analysis has contributed little to our understanding of cerebral function and has often confused the issues, especially in the study of the aphasias. On the other hand, simplified physiological theories of neural integration have hampered the development of psychology and have contributed to a futile sort of psychological atomism. Cerebral physiology and to a large extent the concepts of psychology must be built up from the empirical basis of anatomical and clinical facts, but we can not ignore the problems of integration which are presented by normal behavior. We must not forget, as many of the diagrammatists seem to have done, that cerebral areas somehow do perform the functions which are lost when they are destroyed, and that we must account not only for defects, but for normal activity as well.

Diverse Functions of the Visual Area

To-night I wish to report the results of our attempts to analyze the function of a single field of the cerebral cortex, the visual area. This, of all cortical fields, presents the most definite evidence for fine structural and functional differentiation and at the same time reveals activities which are among the most difficult to fit into any schema of localization. Our approach has been essentially that of Goltz, Munk, Luciani and Hitzig, but with the use of quantitative methods of studying behavior and of analyzing the anatomical findings which were not available to earlier workers.

The experimental work is largely limited to the rat. The advantages of this material are the simplicity of the animal's behavior, its steadiness in activity under the motivation of hunger and its availability in large numbers. The last has made possible the use of experimental and statistical controls which would have been impossible with any larger form.

The danger of generalization from the rat to man is obvious. Our program includes the use of this material only as a means of outlining problems and gaining clues which must in every case be retested by experiments with primates and by comparison with clinical evidence. So far as we have been able to carry out such controls, there has been a clear agreement between the results with the rat and with primates. Actually these lower animals seem to show the beginnings of every human mental trait and I have come to doubt that the evolution of mammals has introduced any change in the fundamental organization or mechanism of cerebral activity. The enormous differences are in degree rather than in kind.

Our present knowledge of the structure of the visual system in the rat is still imperfect. There is a definite visual area of the unistriate type occupying a position on the dorsal convexity of the occipital pole.[2] Volkmann[3] also distinguishes a smaller medial area as homologous with the visual association area of higher forms. From the retina there is a large crossed tract which terminates in the lateral geniculate body and in the superior colliculus. The small uncrossed bundle in Marchi preparations seems to terminate in the lateral geniculate body. From the thalamus a large tract ascends to the striate area. Its exact origin and termination have not been worked out. From the cortical area a large tract descends to the internal capsule, a second smaller tract passes to the callosum. Except for this commissural tract there are no long transcortical fibers from the area.

A word as to methods: for testing vision in animals we have used two types of apparatus. The more familiar type is the discrimination box in which two different visual stimuli are displayed at the ends of

[2] Fortuyn, *Arch. Neurol. and Psychiat.* (London), 6, 221, 1914.

[3] Anat. Anz., Erganzungsheft, 61, 234, 1926.

two adjacent passages, so as to be visible to the animal from the common entrance. The stimuli are alternated in position irregularly on the right or left in successive trials and the animal is trained to go to one of the stimuli for food, in whichever passage it may be displayed. The discrimination box has served for the study of thresholds for brightness but is unreliable for tests of detail vision. For the latter the method is modified so that the animal must jump from a distance against one of two cardboard doors bearing different visual patterns, one of which may be knocked aside to allow him to reach food. This method works rapidly for tests of pattern vision. For testing learning and memory, latch boxes or mazes through which the animal must learn the direct path are used. By these means we may study the limits of visual capacity, such as thresholds, acuity or ability to distinguish complex patterns or to identify pictures with objects, and also the rate at which visual and other associations are formed and the loss of visual and other memories as a result of brain injuries.

The neurological variables which may be studied quantitatively are the locus of lesion with respect to the cortical fields, the absolute extent of destruction, and the time interval between operation and tests. The destruction of cerebral tissue may precede training in tests of the influence of lesions upon the limits of capacity, or may follow in tests of postoperative amnesia. In all cases reported the lesions have been carefully reconstructed from measurements of serial sections.

SPECIFICITY OF FUNCTION IN PATTERN VISION

The rat has a fairly good capacity for pattern vision.[4] He is very near-sighted, the far point being at about 8 cm. His acuity is about 1/60 that of man. With these limitations his vision does not seem essentially different from that of man. He can readily distinguish position, distance, brightness, relative size and complex outlines. If he learns to differentiate between two solid figures he recognizes immediately outlines of them differing in size, or even partial outlines. That is, essentially, he can recognize pictures of objects. He can learn to pick out a variable from a constant part of a complex pattern.

For test of cerebral localization we have made a general survey of the whole cortex, destroying parts, symmetrical on the two hemispheres, with knife or thermocautery.[5] With recovery from the operation the animals were put through a number of tests of vision, then brought to necropsy, and the lesions reconstructed from serial sections. Our tests have now covered about 50 cases with lesions in all parts of the cortex.

Fig. 1 shows the results of the experiments. Destruction of a small region in the lateral part of the visual area completely and permanently abolishes the capacity for detail vision. The animals still jump readily, distinguish the position and distance of single objects and can distinguish between two objects of different size or brightness, but they fail on every test which requires the discrimination of patterns. The defect in vision is no greater if the whole of the occipital cortex is destroyed. Vision for discrete objects, their relative position and brightness is retained after lesions including any part of the cortex.

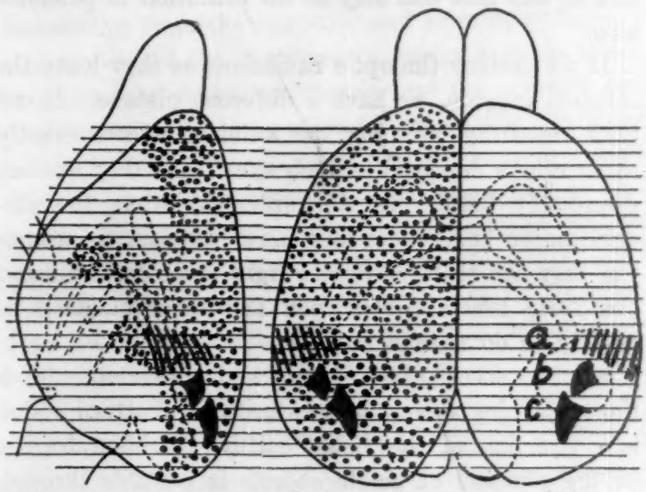

FIG. 1. Visual areas of the cerebral cortex of the rat. The stippled areas represent the regions destroyed by operations, symmetrical on the two hemispheres, without disturbance of the capacity for pattern vision. The coarser stippling indicates the position of the anatomical *area striata*. Destruction of the cortex at b or c on both hemispheres completely abolishes vision for patterns but leaves the capacity to distinguish the position and relative brightness of gross objects, as does the total destruction of the visual cortex. Interruption of the projection fibers at a abolishes all vision for objects but leaves the capacity to distinguish differences in the intensity of light.

We have here, then, a definite restriction of the function of pattern vision to one small area of the cortex. There is no interference with detail vision in our tests after destruction of any other part of the cortex. In all the tests the animals were normal in all visual tests after the destruction of the motor, or somesthetic, or auditory, or of the greater part of the visual area, including the supposed visual association area.

The localization of the visual field is as precise and as absolute as it is in man. Within the field there may be an accurate representation of different parts of the retina. We have no method for mapping

[4] Lashley, *Jour. Genet. Psychol.*, 37, 453, 1930.
[5] *Jour. Comp. Neurol.*, in press.

scotomata in the rat and hence can only infer finer specialization from data on higher animals. Since any other part of the cortex than the visual area can be destroyed without disturbance in our tests, it seems clear that the simple motor habits involved do not require the formation of any special transcortical associations with other fields, but are carried out merely by the coordinated activity of the visual cortex and the subcortical visual and motor nuclei. There are indications in the anatomical studies of Poljak and in the experimental work of Jacobsen and myself that this may be the condition in primates also.

If we destroy the optic radiations as they leave the internal capsule, we have a different picture. In all tests requiring jumping the animals behave exactly as do others deprived of their eyes. Yet they are not completely blind. In a simpler situation, the discrimination box, where they must run past the stimulus, they can still distinguish light from darkness and can form habits based upon this discrimination as readily as do normal animals.

All this seems clear enough and consistent with a thoroughgoing theory of localization. Pattern vision is a function of the visual cortex, the identification of the position of single objects is possible through the action of projection fibers to other than the anatomical visual area, and the discrimination of the intensity of lights may be wholly a function of the thalamus and midbrain.

Limited Specificity in Discrimination of Brightness

But when we study further the function of brightness vision, that is, the discrimination of light from darkness, in the discrimination box, a difficulty immediately arises for so simple an interpretation. In the absence of the entire visual cortex the habit of light-darkness discrimination is formed at normal rate. We have data now on 113 cases with injuries in the visual cortex and 89 normal controls. There is no significant difference in their rates of learning. But if we train normal animals and then subject them to operation in the visual area, they lose the habit. If the entire visual cortex is destroyed, the postoperative amnesia is complete. The animals can relearn to make the discrimination, but require just as much practice as they did for initial learning before operation. This loss can not be accounted for upon the grounds of cortical blindness, for the animals relearn at normal rate and are obviously not blind. It is not a simple sensory defect, for if it were, the defect should show in the initial learning of animals which lack the visual areas, and these are normal in the formation of this habit. We can only describe the loss as an amnesia, in contradistinction to sensory defect.

The next step in our analysis is to determine the effects of partial destruction of the visual area upon the habit based on brightness discrimination. If only a part of the visual cortex is destroyed, the animal shows amnesia but relearns more rapidly than when all is destroyed. It makes no difference what part of the visual area is involved, the effect is the same. In a series of cases the relationship between the extent of lesion and the degree of amnesia is very close, whereas the locus within the visual cortex is immaterial.[6]

These results can be interpreted, I believe, only by assuming that the visual cortex acts upon the lower visual nuclei in such a way as to facilitate their activities in the performance of functions which they nevertheless can carry out in the absence of the visual cortex. There is still localization, in the sense that the visual area and no other part of the cortex exerts this effect, but the effect is independent of that finer localization which is essential for pattern vision. For this function there are not subordinate localizations of functions within the visual cortex, but the area acts as a unit, each part providing energy or facilitation of the lower centers, as does each other part.

We have closely comparable data for the latch-box. This is learned at normal rate by animals lacking any half of the cortex, yet when it is learned by normal animals an amnesia follows the destruction of any part of the frontal region.

Turning now to another aspect of the visual problem: Testing for threshold of discrimination between different intensities of light we find that animals lacking the visual cortex have on the average a higher threshold than normals and that they are slower in learning to choose between lights whose difference is well above their threshold.[7] The disability here does not seem to be one of actual visual defect, so much as of instability of the visual reactions. The animals seem to fail the tests near threshold values, not so much through inability to discriminate as through inability to react consistently enough to reach the high standard of accuracy required as evidence of discrimination. One or two cases, entirely lacking the visual cortex, showed a threshold as low as normal, after long training.

In this case the visual cortex seems, speaking figuratively, to keep the subcortical visual centers on the job, possibly by a facilitation which maintains an increased responsiveness or increased excitability

[6] Lashley, *Jour. Comp. Neurol.*, 41, 1, 1926.
[7] Lashley, *Jour. Genet. Psychol.*, 37, 461, 1930.

without contributing to the specific integrations involved.

This sort of general facilitating action of one center upon another is not unfamiliar in neurological theory, since it forms the basis of Monakow's theory of diaschisis. Our results for the visual field depart from Monakow's theory first in that the functions lost from withdrawal of facilitation do not recover spontaneously, but may be reacquired by reeducation, second, in that the effect may be specific for integrations already formed in learning and need not involve the capacity to form those associations, and third, that the severity of diaschisis is proportional to the amount of tissue destroyed.

There are indications that similar conditions underlie many of the symptoms of brain lesions in higher animals and man. The cerebral paralyses give a picture which is the inverse of the preceding. We trained a group of rhesus monkeys to open puzzle boxes by turning a crank, opening a gate hasp, and the like.[8] Their retention of these problems was found to be perfect after three months. They were then subjected to operation involving removal of both precentral gyri. The resultant diplegia cleared up after three months to permit of fairly deft movements of the hands. During the recovery period the animals did not see the problem boxes. About four months after the operations their ability to open the boxes was tested. All solved the latches practically at once, without random activity, and used the same methods that they had employed before the destruction of the motor cortex.

In this case we seem to be dealing with two mechanisms which have somewhat the relations of the visual cortex and lateral geniculate bodies. Destruction of the motor cortex does not abolish the specific integrations involved in the manipulative habits, but only withdraws a certain necessary mass of facilitation from the total system. This facilitative control is recovered (largely by reeducation, as shown by Odin and Franz[9]), and with the recovery, the organized patterns of movement may again become functional without training. It seems that we must be dealing with two mechanisms, one of which is responsible for the integration of movements in the habit, the other for a facilitation of final common paths to make them responsive to the excitations from the former. Both are almost certainly cortical functions and both are essential conditions of the normal activity.

I suspect that some of the phenomena of motor aphasia or anarthria fall in this class of disturbances. From experiments upon movements of the tongue in speech and in silent thinking we have evidence that overt speech includes both a general increase in the tonus of the vocal organs and also a specific innervation which determines the patterns. The tonic innervation holds the tongue forward in the speaking position and in this position even during silent thinking there are sometimes involuntary movements of speech. With relaxation the tongue drops to the back of the mouth and the involuntary movements disappear. The suggestion is that Broca's area or Marie's quadrilateral provide a tonic innervation which makes the lower motor centers responsive to weaker impulses descending from the temporal and angular gyri.

A survey of the literature on motor aphasia which we have been making indicates that the severity and duration of symptoms after injury to the left third frontal convolution are proportional to the extent of destruction and independent of locus within this region. The assumption that the function of Broca's area and of Marie's quadrilateral is a non-specific facilitation of lower centers may help to clear up some of the difficulties of localization which have been encountered in study of these areas.

NON-VISUAL FUNCTIONS OF THE "VISUAL" CORTEX

In the experiments which I have thus far discussed the function of the visual cortex is visual, although exercised in various ways. We have now to consider what seems to be an entirely different function of this same area. If we subject animals to cerebral lesions and then train them in a fairly complex maze, we find that they learn much more slowly than do normal controls.[10] This slowness of learning appears, no matter in which part of the cortex the lesion occurs. The degree of retardation seems proportionate to the amount of tissue destroyed, irrespective of the locus of injury.

Fig. 2 illustrates the relationship between the extent of destruction of the cortex and the amount of training necessary to perfect the habit. The correlation is 0.84 which is as high as that between any two measures of learning ability or of intelligence that we have. The lesions included in the graph cover all parts of the neocortex and, within the limits of their statistical reliability, the data indicate that equal amounts of destruction in the motor, somesthetic, auditory or visual areas are attended by equal amounts of retardation in learning.

If normal animals are first trained in this habit and then are subjected to cerebral lesions they show loss of the habit irrespective of the locus of the lesion and in proportion to the extent of destruction. That is,

[8] Lashley, *Arch. of Neurol. and Psychiat.*, 12, 249, 1924.

[9] *Psychobiol.*, 1, 33, 1917.

[10] Lashley, "Brain Mechanisms and Intelligence," Chicago, 1929.

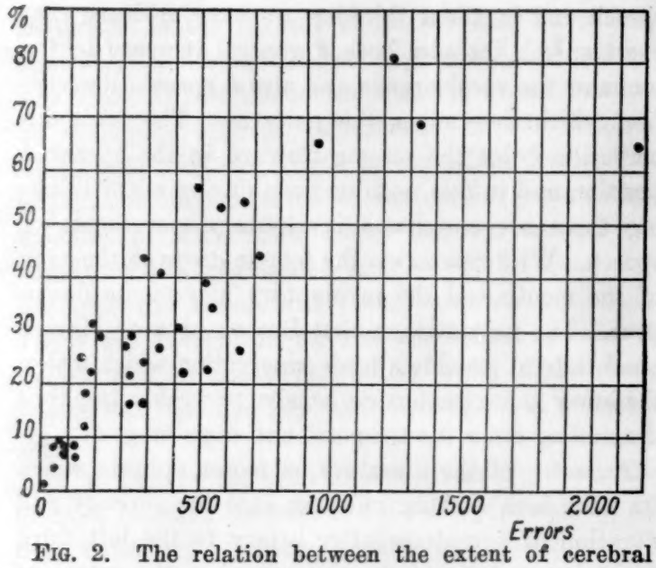

FIG. 2. The relation between the extent of cerebral lesion and the amount of practice necessary for the learning of a complex maze. The ordinates represent the percentage of the neocortex destroyed; the abscissae, the number of errors made during training to a constant standard of efficiency. The graph includes about an equal number of cases with lesions in each of the chief cytoarchitectural areas. (*After Lashley, 1929.*)

every part of the cortex plays a part both in learning and in retention.

Like other cerebral fields, the visual cortex contributes to the learning and retention of this habit of threading the maze. But in this its function is apparently not primarily visual, as shown by experiments like the following: We trained a group of animals until they reached a certain standard of accuracy in running the maze. We then blinded them by enucleation of the eyes. This produced no inaccuracy of performance. In the first tests after blinding the animals make errorless records in the maze. Another set of animals was blinded before training, and learned the maze without seeing it. They were then subjected to lesions within the visual cortex. They showed a loss of the habit—a loss as great as the loss in seeing animals after the same type of lesion. They were retrained and required an amount of practice for relearning which seemed proportionate to the extent of injury within the visual field.

These facts, that blindness does not interfere with efficiency in this activity whereas destruction of the visual cortex in blind animals does seriously interfere, indicate that in this habit the visual cortex has some important non-visual function. Since in this same manner each of the cortical fields seems to contribute equally to the maze habit, we have been led to the conclusion that the various parts of the cerebral cortex exert a mutual influence, each contributing, perhaps by some sort of facilitation, to the functional efficiency of the others, or to the functional efficiency of some lower centers which all the cortical areas supply in common.

Whether there are cortical integrative processes in the maze habit or only a general facilitation of subcortical integrative processes is not certain. There are indications, however, that the same non-specific quantitative relations obtain in the integrative activities of subcortical nuclei. Thus, injuries to the lateral geniculate bodies result in a slowing of the formation of habits based upon brightness discrimination and within our limited data the retardation seems roughly proportional to the amount of destruction.

We have been inclined to interpret this mass facilitation in the cortex as somehow underlying the intelligent activities of the organism. When we compare the effect of the same amounts of cerebral destruction upon functions of varying difficulty we find that, in general, the more complicated the function the more it is affected by a given amount of destruction. For the simplest habit (a maze with one blind alley) the extensive lesions produce little more retardation than the slight, whereas for a more complex maze the retardation is almost proportional to the square of the extent of destruction. For still more difficult functions, which seem to require of the animal something analogous to reasoning in man, Dr. Maier finds that small lesions produce more marked effects and a destruction of 20 per cent. of the cortex may entirely abolish the function.[11]

These experiments give us a picture of a cortical field in which for some activities the efficiency of performance is proportional to the quantity of tissue available and is independent of any known specialization of the parts. Moreover it seems fairly established that the complex functions of such a field may be seriously hampered by lesions which leave the simpler functions almost undisturbed.

We have further evidence on this latter point from the experiments of Dr. Carlyle Jacobsen with monkeys.[12] The animals were taught to open various latch-boxes and their rate of learning measured for simple and for combination locks. They were then subjected to destruction of the frontal lobes of the cerebrum. After the operation they remembered quite well the problem boxes on which there was a single latch to be opened and learned new problems of this type at normal rate, but when the boxes combined several of the same simple latches, the animals were unable to recall the solutions and were much retarded in relearning them. Destruction of the frontal areas generally left the capacity to deal with simple situations undisturbed yet interfered greatly

[11] *Jour. Comp. Neurol.*, in press.
[12] *Jour. Comp. Neurol.*, in press.

with the ability to handle combinations of these same simple situations. Something of the same effect appeared after destruction of the parietal association areas.

Many symptoms in man are suggestive of the same type of organization. In organic dementia we may find the ability to execute each of several simple tasks unimpaired, along with an inability to follow instructions which call for the successive execution of these same tasks. In the agrammatic aphasia of Pick there may be little or no amnesia for words but an inability to combine the words in grammatical sequence.

Boumann and Gruenbaum[13] have defined the more general defect of aphasia as an inability to keep in mind the several elements of a complex situation and at the same time to manipulate the elements in thought. With our animals there is an inability to deal with problems which present several elements at once.

Anatomical and Functional Levels of Organization

Our results with mazes of different complexity point to a functioning of cortical fields at different levels of organization. We have already clear evidence that different levels of complexity of organization may correspond to different anatomical levels (as in the case of brightness vision mediated by the thalamus and pattern vision by the cortex) and this has been accepted as a characteristic neural arrangement; the existence of hierarchies of organization in different anatomical loci. But our results with activities which probably represent the highest levels of integration of which the animal is capable suggest that for these activities there is not separate anatomical localization, but that anatomically the mechanism for the highest integrations is coextensive with the mechanisms for simpler ones. The simplification of behavior after cerebral lesions is in these cases not the result of destruction of a super-associative center, but of destruction of tissue anywhere within the cortex. The limiting condition for efficiency is the surface area or mass of cortical tissue and not the specific anatomical relations of the parts.

This is essentially the problem of the relative fragility of functions. Where one function is eliminated by a lesion which leaves other similar functions intact, it has been customary to postulate their separate localization, as in the case of color and pattern vision in man. But it seems also possible that such differential fragility may result from disturbances within a single area and that one limiting condition of the complexity of integration is the amount of available tissue.

[13] *Zsch. f. d. ges. Neurol. u. Psychiat.*, 96, 481, 1925.

Non-Specificity of Histological Elements

Thus far I have dealt with gross relations of parts of the visual and other areas. What of the finer relations and the specialization of the histological elements? The separate projection of parts of the retina upon the calcarine region of higher mammals is well established and there may well be a point-to-point correspondence between the ganglion cells of the retina and the cells of the stripe of Vicq d'Azyr of the striate area. But does this mean a determination of the reaction through the specialization of these cells?

We blindfold one eye of a rat and train him to react to one of two visual stimuli. We then transfer the bandage to the other eye and test his ability to react to the stimuli with the untrained eye. The response is perfect without training. Here we have a reaction learned with one set of receptors and executed immediately with a different set. Of course the corresponding cells of the two retinae may excite the same cells of the central system, so the experiment is not crucial.

But, if we train the animal to jump to a white erect triangle and to avoid an inverted one and then confront him for the first time with outlines of these figures in smaller size, he will choose the correct outline without error. Here none of the retinal cells and consequently none of the cells of the projection area which were stimulated by the contour of the figures during training are similarly stimulated by the contours of the test figures. The habit is formed by one set of cells and immediately executed by another. It seems clear in this case that the reaction is not dependent upon the particular cells stimulated. Within limits, any cells of the visual projection area if excited in specific relation to one another can mediate the performance of an habitual act, regardless of whether they have been similarly excited during learning.

I have not time to present other examples of this same condition, but I believe that in every reaction, above the level of a spinal reflex to protopathic stimulation, the adequate stimulus is a pattern which is effective when applied anywhere upon the sensory surface and the motor response involves an equally variable grouping of motor neurons. That is, no two repetitions of the same instinctive or habitual act need involve the same pathways of conduction through the central nervous system, or the same nerve fibers excited in the same way.

Professor Herrick[14] has recently defined two types of localization.

> First, a known localization of stable structural elements whose functions also are known, and, second, a localiza-

[14] Proc. Nat. Acad. Sci., 16, 643, 1930.

tion of fields within which various recurring patterns of performance or schemata, are known to be fabricated and within which inhibition, modification, or conditioning of these patterns takes place.

The second of these is the only type of localization which can be defined in the adult organism. In it the strict localization even of reflex units seems impossible. For spinal reflexes the conception of simple point-to-point connections is proving inadequate and giving place to a less specific and more dynamic interpretation. Subliminal effects, overlap of fields of influence of neurons, and the like have led Sherrington[15] to the conclusion:

> Though trains of impulses are the sole reactions which enter and leave the central nervous system, nervous impulses are not the sole reactions functioning within that system. States of excitement which can sum together, and states of inhibition which can sum together, and states which represent the algebraic summation of these two, are among the central reactions. The motoneurone lies at a focus of interplay of these reactions and its motor unit gives their net upshot always expressed in terms of motor impulses and contraction.

Thus, wherever we turn in the study of the central nervous processes we are confronted by the same problem. Just as our data show that for some functions it is massed relations of facilitation and not the specialization of separate parts which is responsible for efficiency of performance, so within the finely localized areas the ultimate element of organization can not be the single cell and its specific anatomical connections but is the interplay of organized patterns of excitation in which *relative* position and mass of excitation play a dominant rôle.

Interpretations

The picture of cerebral functions arising from this work is not a simple one and it is still far too early to attempt any complete account of the cerebral nervous mechanisms. The point which stands out most clearly is the fact that the laws governing the activity of cerebral areas vary according to the functions involved. For pattern vision, the spacial distribution of the visual cortex is of fundamental importance and the different parts contribute diversely to the reaction. But for brightness vision, although the cerebral visual area as a whole plays an important part, its individual parts do not have a differential function but contribute equally in some unknown way to the maintenance of the habit of discrimination. In more complex functions, such as the learning and retention of the maze habit, the visual area seems essential yet non-specific, contributing facilitation to the total neural organization yet essentially equivalent to other cortical areas. The same area may at times function as a highly differentiated system, at others as a unitary mass.

There can be little question of the facts in each case. The experimental and clinical evidence for such diverse modes of functioning seems conclusive. Our task is to find the conditions under which the different types of neural activity occur and to analyze the interactions among them. Any claim to certain knowledge of the mechanisms of cerebral function would be presumptuous, but from the known facts we may gain suggestions which will be of value in the formulation of further research and in giving at least a vague notion of how some of the simpler cerebral integrations are brought about.

The structural elements, projection and association fibers, determine the main lines of conduction and limit the regions of major excitation. The afferent projection fibers transmit their excitations to diverse parts of the cortex and, at least in the case of vision, kinesthesis and touch, reproduce on the cortex something of the spacial attributes of the stimulus. We have seen that the adequate stimulus in such cases is not the specific cells activated, but the pattern of excitation which may shift over the sensory surface and likewise over the cortical field. In such a pattern the relative intensity, distance of separation and frequency of excitations seem to be the only constant factors, determining in turn the direction and steepness of gradient of electrical and chemical processes within the system.

These patterns are certainly not transmitted in duplicate beyond the sensory projection surfaces. They give rise to specific patterns of movement but these do not reproduce the sensory pattern and we can not assume a direct connection between them over preformed and specifically differentiated paths. Yet we must assume that specific sensitivity of motor patterns to sensory patterns does exist.

We know that many of the details of motor integration are organized within the motor nuclei themselves and that the cortex does little more than activate these motor patterns, determining which of several integrated systems will respond. There are indications, further, from embryologic studies that, in their growth and early functioning, the motor systems are sensitive to the general direction of polarization of the body. It is not inconceivable that the cortex determines the reactions of lower centers, not by activating individual cells or cell groups but by determining the general direction and degree of polarization of the motor centers. There are suggestions of this in the results of

[15] Proc. Roy. Soc., 1929, B, 105, 332.

Weiss[16] with transplanted limbs of Amblystoma, in the ready shift from one limb to another in the execution of semi-skilled movements,[17] in the tendency of athetoid movements in hemiplegia to reproduce the general direction and rhythm of movements on the sound side and the like. It is as though the influences descending from the higher centers tend to call out the same direction and rhythm of movement from any motor center which they reach, regardless of whether specific associations with that center have been previously formed or not.

Turning back to patterns of excitation in the cortex, we find them projected from sensory surfaces to cortical fields in such a way that the *relative* position and intensity of activity in the various parts alone are stable. The chief interconnection of the cortical fields is through arcuate fibers which form a veritable feltwork and give little suggestion of any specific projection of one field upon another. Similarly, there are indications that the adaptive control of lower centers is in part by way of the diffusely distributed extrapyramidal fibers and the arcuate fibers of the cord. As examples, I have already cited the fact that pattern vision is mediated by the efferent fibers from the visual cortex only and may mention as an additional example that we now have animals which have learned semi-skilled acts after the section in the cervical region of all the long ascending and descending fiber tracts of the cord.

Such facts suggest that integrations above the level of the sensory fields may be in part a matter of diffusion of impulses through a fairly homogeneous matrix. In the case of any physical analogy which we can draw with this condition, such as chemical diffusion, wave motion, or the spread of timed volleys of nerve impulses through a homogeneous cellular network, there will arise within the matrix a definite and stable interference pattern in which, although the transmitted energy is in a state of constant flux, the lines or points of maximal and minimal summation and interference maintain a constant position. Such an interference pattern would in turn be capable of exciting specific groups of efferent cells and determining a definite pattern of motor innervation, or, if less specific, of altering the general polarization of lower centers and so modifying their functional activity.

This is a possible mechanism which would permit of some such degree of plasticity as the results of our experiments seem to require. It would allow of the excitation of definite motor patterns by sensory patterns of entirely different form, without the intervention of specific neural connections. It is, of course, still purely hypothetical, but it is an hypothesis which is in harmony both with the facts of localization and with the apparently contradictory facts of equipotentiality and mass action of neural tissue.

This is only a part of the whole story. There is evidence that the activity of every nervous center is conditioned by a variety of factors. Its general level of excitability varies and a low threshold or state of tonic activity is maintained by excitation from many sources. Steadiness and continuity of discharge are likewise maintained by agencies other than those which are concerned in the specific patterning of reactions. In addition, there are many indications of a preliminary integration or setting of nervous mechanisms which may then maintain a potential organization until activated by excitation from other sources. Thus it is possible, by brief stimulation of a motor point in the cortex, to modify the motor responses elicited on stimulation of distant points and such an altered excitability or motor set may persist for an hour or more before it gives way to the original pattern of response.

These processes, which we may term priming, steadying and preparatory adjustment, seem to be subthreshold for overt activity: some sort of partial activation or tonic excitation of centers. In addition to these, there are activating mechanisms which perhaps impose additional patterns of integration or perhaps only raise the tonic excitation above the threshold for motor expression.

In the motor field we have evidence that many structures participate in activity without actually determining the specific pattern of skilled movement. Thus the cerebellum, the striate complex, and probably the motor cortex contribute to the readiness and steadiness of response, though their destruction does not abolish the pattern of skilled movement. We do not know the prevalence of such facilitating activities, but our work suggests that the whole cerebral cortex, perhaps every part of the nervous system may, in addition to its specific functions, exercise such general facilitating effects upon other parts. This may account in some measure for the quantitative relations found between extent of lesion and efficiency of performance, the extent of facilitation depending upon the number of cells activated.

The apparent limitation of possible complexity of function by the available amount of tissue seems to raise a different problem. The limitation can not be due to restriction of the number of possible conditioned reflex paths available, for the animal can form as separate habits all of the elements which can not be combined in one reaction. The difficulty is in dealing with a number of elements at the same time.

[16] *Jour. Comp. Neurol.*, 40, 241, 1926.
[17] Lashley, *Psychol. Rev.*, 31, 369, 1924.

A possible clue to the situation here comes from experimental biology. In the regeneration of hydroids the number of tentacles regenerated is correlated with the size of the regenerating mass of tissue. Child has shown that each separate structure develops from a nodal point in the system of gradients within the mass. He has suggested that there is a minimal distance of separation for the development of diverse gradients limiting the number of structures which can be formed by a small piece of tissue.

In the simultaneous integration of a number of activities the cortex must present a large number of nodal points of excitation and it is possible that the number and distribution of these within the association areas is determined not by specific connections but by the polarization effects of the various localized excitations within the sensory projection fields. In such a case the number of nodes of excitation and of diverse gradient fields would be definitely limited by the factor of separation and of available mass of tissue.

I have indulged in this highly speculative discussion primarily to show that the notion of decentralization or of cerebral function without absolute anatomical localization need not involve an abandonment of recognized physiological principles or a denial of the known facts of localization. The chief advantage of the strict theories of localization has been their definiteness and comprehensibility. Those of us who have felt the inadequacy of such theories have had to fall back upon expressions like mass action, stress patterns, dynamic effects, melodies of movement, vigilance or nervous energy; all highly metaphorical and unproductive of experimental problems. Yet the facts demand something of this sort. The evidence seems conclusive that in various cortical functions there is every degree of specialization from a limited point-to-point correspondence of cells to a condition of absolute non-specificity. Not only is there diversity in the modes of action of different parts of the cortex but a single area, highly specialized and differentiated for one activity may be wholly undifferentiated with respect to another in which it also participates. We have not a choice between a theory of localization and a theory of decentralization, but must develop a wider view which recognizes the importance and interdependence of both modes of integration.

The principles to which I have appealed in the foregoing sketch, the production of gradients of activity and their influence upon organic processes, the development of stable patterns of interference in the transmission of different forces through a homogeneous matrix, are as well established in biological thought as are the principles of conduction within the nerve fiber or the interaction of nervous impulses within a spinal center. They will be capable of test with further improvement in our methods of studying the electrical phenomena of nerve conduction. Whether these specific suggestions prove right or wrong, they indicate, I believe, the direction to which we must turn our investigations, if we are to develop an adequate cerebral physiology.

OBITUARY

IGNATIUS URBAN

THE really capable and active systematic botanists of the world are so woefully few that the removal of a single one vacates a niche that usually remains unfilled. Such losses seem to have been more than normally frequent during the past year. In 1930 the world was deprived of Dr. Adolf Engler, dean of German botanists. Only a fortnight ago news was received of the death in Copenhagen of Dr. C. H. Ostenfeld. On January 7 the Botanical Garden and Museum of Berlin-Dahlem was robbed by death of another of its most brilliant men, Dr. Ignatius Urban.

Dr. Urban's special field was the flora of the West Indies, to which he devoted forty busy years. He found the Antillean flora in chaos, and left it in order. It is safe to say that for no other part of America is there available in convenient form so well ordered a mass of exact information as exists for the West Indian flora in the nine volumes of the "Symbolae Antillanae."

Those volumes by no means represent the whole extent of Dr. Urban's work, for he published many papers in German and Swedish journals. The "Symbolae" contain a vast amount of ably presented information regarding West Indian plants—descriptions of new species, monographs of genera and critical notes upon nomenclature, besides chapters upon botanical history and bibliography and plant geography. One of Dr. Urban's greatest services to science was his careful solution of the status of many vague names appearing in early literature but long neglected. He did more than any other man to place nomenclature of tropical American botany upon a solid and sane basis. His floras of Porto Rico and Hispaniola, which constitute two volumes of the "Symbolae," must be consulted almost daily by students of tropical plants.

Few botanists of all time have accomplished so much and that so uniformly well. Whoever consults Dr. Urban's own pages of the "Symbolae" will be

amazed at the wealth of painstaking detail, presented so lucidly and concisely. The descriptions of new species are models of accuracy and completeness such as scarcely a single botanist of the present generation can or will try to follow. In his ability to judge specific and generic values he had few peers. His conservative but nevertheless progressive and modern treatment of such units puts to shame the hasty and often irresponsible publications of many of his contemporaries in both Europe and America.

A fitting climax to Dr. Urban's life work was his study and description in recent years of the extraordinary collections made in Cuba and Hispaniola by Dr. Erik L. Ekman. It had been supposed by some botanists that the flora of the Antilles was practically exhausted, at least so far as discovery of new species was concerned, but Ekman's explorations showed the fallacy of such a supposition. His work in those islands revealed hundreds of new species and numerous genera quite as distinct as any ever described.

The study of these collections engaged happily Dr. Urban's youthful enthusiasm until the very time of his death. The voluminous reports upon them that have come so frequently from his pen during the last few years show that age had not abated his industry or dimmed his keen discrimination.

Dr. Urban may be envied for the fact that the end came with little warning, and that he was able to continue his habitual activity in the herbarium until the time of his death. As a friend writes, "Fortunate the man who can go in the midst of contentment, and without suffering."

American botanists who have visited Berlin will be saddened by the announcement of the death of Dr. Urban, for all of them speak of him with genuine affection and esteem. His courtesy and sympathy toward them were unaffected and unfailing.

The writer knew Dr. Urban only by his publications and through kindly letters received at all too infrequent intervals. Nevertheless, so vivid an impression of his personality did these leave that he always was felt to be an intimate friend of long acquaintance, and the news of his passing was received with a deep sense of personal loss. To the field of West Indian botany the loss is a catastrophe, for there is no promise of an adequate successor to the place which Dr. Urban held.

PAUL C. STANDLEY
FIELD MUSEUM OF NATURAL HISTORY

ERIK L. EKMAN

SCARCELY had there been placed in the mail an obituary notice of Dr. Ignatius Urban, when there was received, through the kindness of Dr. R. Ciferri, an announcement of the death in the Dominican Republic on January 15 of Dr. Erik L. Ekman. Dr. Urban was so advanced in years that his loss was not altogether unexpected, but Ekman was only forty-six, and of such rugged and vigorous physique that many more years of his habitual restless activity might confidently have been expected for him.

Already trained by field work in South America, Ekman went to Cuba early in 1914, and devoted the rest of his life to an investigation of the plant life of that island and Hispaniola. Cuba, it was presumed, had been rather well explored by earlier collectors, local, European and North American, but his work proved that theirs had been far from thorough. In Hispaniola the situation was somewhat different. The island was explored botanically a century ago, but for long years afterward it was difficult to travel there. Ekman's tireless industry led him to every corner of Haiti and the Dominican Republic, to many spots which no foreigner ever had seen. He said to the writer on one occasion, "When I have finished with Haiti, it will be hard for any other collector ever to find a new species there." This boast he undoubtedly made good.

Happily, he was able to complete to his satisfaction his exploration of Hispaniola. At the time of his death he was on the point of sailing for Venezuela, where he could expect to surpass even what he had accomplished in the West Indies. What he already had done was a life work for any man. In both Cuba and Hispaniola he had discovered hundreds of fine new species, and many equally good genera, besides adding to their recorded floras scores of plants already known from elsewhere.

Ekman had as many eccentricities as characterize most other scientists. No one who met him ever could forget him. He attracted much comment in Haiti by his frugality, which was the result of the limited means at his disposal, his utter indifference to conventions and his complete absorption in his work. Would that other naturalists might emulate him in devoting more pages to science and fewer to food and weather! He was bluntly frank in speech, a consequence of his well-founded confidence in his own knowledge. He had a profound scorn for shabby and incompetent work. His specimens and his acquaintance with the plants from which they came left nothing to be desired.

The writer once had an opportunity of witnessing for a few hours the manner in which Ekman botanized. He covered a rocky hillside with the agility of a wild animal, and attacked it as if it were an adversary. Heat and storm and hardship of travel were for him beneath consideration. It was thus that he was able to explore the remotest and most difficult mountains, where others feared to go. His perfect acquaintance with every Haitian plant enabled him to recognize immediately any new one that he saw.

For that reason he shared with Dr. Urban author-

ship of many new species that he discovered. He published also numerous entertaining and scientifically valuable papers upon plant geography, especially that of Hispaniola, and he wrote an admirable monograph of the tropical American *Vernonieae*. Botanical science will be vastly poorer for loss of other contributions that it hoped to receive from his pen.

It is a strange coincidence that Urban and Ekman, the two men who have contributed most to knowledge of the Antillean flora, should have ended their labor only a week apart. Ekman's life work was one which all botanists may envy, but very few may equal. He was a brilliant member of that long line of Swedish botanists who have made such eminent contributions to natural science.

PAUL C. STANDLEY
FIELD MUSEUM OF NATURAL HISTORY

RECENT DEATHS

DR. PIERRE A. FISH, dean of the College of Veterinary Medicine at Cornell University since 1929, when he succeeded the late Dr. Veranus A. Moore, died on February 19. He was sixty-six years old on February 17.

DR. JOHN CONRAD HEMMETER, from 1903 to 1922 professor of physiology and clinical medicine at the University of Maryland, died on February 25 at the age of sixty-seven years.

PHILIP P. QUAYLE, physicist for the Phillips Cartridge Company, and formerly a member of the staff of the Bureau of Standards, died suddenly at Lebanon, Ohio, on February 21. Mr. Quayle was a recognized authority on ballistics and had written the article on Spark Photography for the new edition of the "Encyclopaedia Britannica."

THE REVEREND CHARLES DOUGLAS PERCY DAVIES, of Kemerton Grange, Tewkesbury, president of the British Astronomical Association from 1924 to 1926, died on February 5.

SCIENTIFIC EVENTS

INSTITUTION FOR SURGICAL BIOLOGICAL RESEARCH AT DOWNE

THE London *Times* states that the Council of the Royal College of Surgeons has accepted an offer from Mr. George Buckston Browne, F.R.C.S., to build and endow an Institution of Surgical Biological Research upon a 13-acre estate at Downe, Kent, which he proposes to present to the college for this purpose. At a council meeting on February 12 it was resolved that the council expressing its deep sense of Mr. Buckston Browne's great liberality, should undertake on behalf of the college to be responsible for the proposed institution, subject to an approved settlement under a deed of trust.

The estate concerned lies 16 miles from Charing Cross, adjoining the western side of Darwin's old home, "Down House," which was presented, with its 23 acres of ground, to the British Association two years ago by the same benefactor. Mr. Buckston Browne has announced his willingness to endow the new estate with an initial sum of £50,000, and to add further gifts or legacies until his total benefaction to the research institution (including the cost of the land) reaches the amount of £100,000.

In his letter to Lord Moynihan, president of the Royal College of Surgeons, and the members of the council, Mr. Buckston Browne states his belief that those who have added or are adding to the science and art of surgery are the greatest of all benefactors of the human race and the domesticated animal kingdom. He expresses, therefore, a wish to form an institution in which surgeons, and particularly young surgeons, will have full opportunity for carrying out their investigations.

The ultimate size and design of the building to be erected, and the form of equipment, service and staff are not laid down by Mr. Buckston Browne, but for the needs of the present laboratory workers, and of those surgeons who are now seeking an opportunity for testing inferences drawn from the clinical observation of certain diseases, he proposes the following initial provisions:

(1) Three or four laboratories where investigations can be made under the best conditions, or where living animals can be closely observed and cared for.
(2) Houses for animals.
(3) Accommodation for a chief attendant, skilled in laboratory methods.
(4) Accommodation for a stockman, who will look after and feed the animals.
(5) Hotel accommodation for those who may wish to carry on continuous work in the institution.

OBSERVATIONS FOR THE DETERMINATION OF LONGITUDES

A PUBLICATION has been issued by the United States Coast and Geodetic Survey concerning observations for the determination of longitudes made simultaneously in 1926 by some 30 countries. The author, Clarence H. Swick, chief of the Section of Gravity and Astronomy, gives information about a world-wide longitude net of 40 basic stations determined in 1926.

The Coast and Geodetic Survey, representing the United States, took part in this project by making the observations at 2 of the 40 stations—one near Honolulu and the other near Manila. The publication includes a description of the instruments, some of which are illustrated, and the methods employed at these two stations, together with complete details of the observations and a summary of results.

Many of the stations of the network are at astronomical observatories where elaborate equipment, such as precision clocks and large astronomical instruments, was available. The Honolulu and Manila stations of the Coast and Geodetic Survey were strictly field stations where portable equipment had to be used, and where many formidable difficulties were encountered.

For many years the determination of longitude, especially at sea, was a very serious problem. Near the beginning of the nineteenth century, prizes amounting to many thousands of pounds in value were offered by British organizations to any one who could devise more accurate methods than the ones then available.

The invention of the chronometer was the first great step in the solution of the problem, as it enabled the mariner to carry the time of his home port quite accurately and to compare this time with his time determined at sea. The difference in the two times gives the difference in longitude.

The next great improvement in longitude determination which, however, could be used only on land, resulted from the invention of the electric telegraph, which gave a means for the direct comparison of the times between some known point and a new point.

The last great advance in longitude methods came with the advent of the radio. The radio made possible a very precise comparison of times over both land and sea and was at once adopted for practically all longitude work. This was the method used for the international longitude net in 1926.

THE OHIO ACADEMY OF SCIENCE

THE forty-first annual meeting of the Ohio Academy of Science has been arranged as a joint meeting with the Indiana Academy of Science and the Kentucky Academy of Science. It will be held at Miami University on April 2, 3 and 4.

The program will conform in the main to the following outline, the details of which will be announced later:

THURSDAY, APRIL 2:

Afternoon—Short field trip to points of local interest for those who arrive in time and care to go.

Evening—An informal gathering probably with a short address on some subject of general interest, followed by a social hour for acquaintance sake.

FRIDAY, APRIL 3:

Forenoon—Short business session, Ohio Academy of Science, followed by a general scientific session with three 30-minute addresses by the presidents of the three academies. Demonstrations.

Afternoon—Sectional meetings.

Evening—Banquet, popular address, social hour.

SATURDAY, APRIL 4:

Forenoon—Short business session, Ohio Academy, followed by sectional meetings, beginning at 9:30.

Afternoon—Sectional meetings and another field trip if desired by a sufficient number.

The membership of the program committee is as follows:

Secretary: William H. Alexander, Columbus, *chairman.*

Zoology: Wencel J. Kostir, Ohio State University, Columbus.

Botany: J. Hobart Hoskins, University of Cincinnati, Cincinnati.

Geology: Frank J. Wright, Denison University, Granville.

Medical Sciences: Charles G. Rogers, Oberlin College, Oberlin.

Psychology: James P. Porter, Ohio University, Athens.

Physical Sciences: L. W. Taylor, Oberlin College, Oberlin.

Assisted by

N. E. Pearson, *chairman,* Program Committee, Indiana Academy of Science.

Alfred M. Peter, secretary, Kentucky Academy of Science.

THE YALE OCEANOGRAPHIC EXPEDITION TO THE BAHAMA ISLANDS

A STUDY of the physics and chemistry of the ocean, and the effect of various environmental factors upon deep sea life will be made by an expedition undertaken under the auspices of the Bingham Oceanographic Foundation of Peabody Museum, Yale University, to explore the water around the Bahama Islands. Plans of the expedition, of which Gifford C. Ewing, Yale '26, of New York, is sponsor and director, have been announced by Dr. Albert E. Parr, curator of the Bingham Oceanographic Collection.

The expedition has sailed for the Bahama waters on Mr. Ewing's schooner *Abenaki,* a 50-foot gaff-rigged Alden schooner, equipped with an auxiliary 50 h. p. gasoline engine giving it a speed of eight knots under power. For the purposes of the expedition a specially designed winch with 7,000 feet of 5/32 inch steel aircraft cable on a drum was installed, taking its hoisting power by chain drive directly from the main engine of the boat. By means of this winch and wire it will be possible for the expedition to carry on observations of the physics and chemistry of the ocean down to a depth of 1,000 fathoms, and an intensive study will be made by the modern method of

using a series of deep sea samplers, with corresponding thermometers, attached to the cable at different levels.

It is the purpose of the expedition to study further the physical conditions in these waters in which, in 1927, the third oceanographic expedition of the "Pawnee," sponsored and directed by Harry Payne Bingham, Yale '10, of New York City, obtained the greatest part of the valuable collections of deep sea life now deposited in the Peabody Museum as the Bingham Oceanographic Collection.

The waters around the Bahamas are known for the configuration and relative positions of the two deep sea troughs or valleys, the Tongue of the Ocean and Exuma Sound, extending in between the Bahama Islands. Running nearly parallel and very close together for almost their entire lengths, these two troughs open towards the outer ocean at opposite ends far apart from each other.

It is hoped that the *Abenaki* expedition may bring the first step forward towards a knowledge and understanding of what actually takes place between the Antilles and Brazilian currents. In this manner the expedition will also be laying the groundwork for the Yale Oceanographic Expeditions to be undertaken during 1932–1937, by arrangement between the university and Mr. Drayton Cochran, Yale '32, and by which it is hoped that it will be possible to carry through an oceanographic exploration of the entire region west of the outer chain of islands from Florida to Brazil.

Mr. Ewing, sponsor and director of the expedition, will conduct the investigations and, with the assistance of Mrs. Ewing, will take care of the observations and collections to be made on board the schooner. He will subsequently undertake the analysis and elaboration of his results in the Bingham Oceanographic Laboratory of the Peabody Museum.

SCIENTIFIC NOTES AND NEWS

THE Echegaray medal of the Royal Academy of Sciences of Madrid has been awarded to Lord Rutherford. According to *Nature* previous recipients of the medal are: José Echegaray (1907), Eduardo Saavedra (1910), Prince Albert I of Monaco (1913), Leonardo Torres Quevedo (1916), Svante Arrhenius (1919), and Santiago Ramón y Cajal (1922).

PROFESSOR SIR J. J. THOMSON, master of Trinity College, has been appointed the delegate from the University of Cambridge to the centenary of the British Association for the Advancement of Science to be celebrated in London from September 23 to 30, and to the Faraday celebrations to be held in London on September 21 and following days.

AT the University of Glasgow on January 20, Sir Frederick Gowland Hopkins, president of the Royal Society, on behalf of the subscribers, presented to Professor Robert Muir, professor of pathology in the university, his portrait by Mr. G. Fiddes Watt, and to the university a bust by Mr. G. H. Paulin. Principal Rait, who presided, expressed his pleasure that Sir Frederick Hopkins should inaugurate his presidency of the Royal Society by going to Glasgow to do this honor to Professor Muir.

M. E. FABRY has been elected a correspondent for the section of geometry of the Paris Academy of Sciences.

DR. JEAN DEMOOR, professor of physiological biology in the University of Brussels, has been elected president of the Royal Academy of Medicine of Belgium for 1931.

THE Gamma chapter of the honorary physics fraternity at Pennsylvania State College, Sigma Pi Sigma, initiated, on February 21, Dr. Artur Haas, professor of physics at the University of Vienna, as an honorary member. Dr. Haas had given three lectures at the college.

THE Lamme Medal of the American Institute of Electrical Engineers has been awarded to Dr. William J. Foster, Schenectady, New York, "for his contributions to the design of rotating alternating current machinery," and will be presented at the summer convention of the institute which is to be held in Asheville, North Carolina, from June 22 to 26. The Lamme Medal was founded as a result of a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric and Manufacturing Company, who died on July 8, 1924, to provide for the award by the institute of a gold medal to a member, "who has shown meritorious achievement in the development of electrical apparatus or machinery."

DR. G. O. HIGLEY, head of the chemical department of Ohio Wesleyan University, has retired from active service. His former students are subscribing to a fund to be used for the establishment of the G. O. Higley Chemical Library.

DR. MARCUS BENJAMIN, editor of the publications of the U. S. National Museum since 1896, retired from active government service on January 31. A dinner in appreciation of Dr. Benjamin's work was given at the Cosmos Club on February 21. Dr. Charles G. Abbot, secretary of the Smithsonian Institution, presided and the speakers included Dr. R. S. Bassler, head

curator for geology, U. S. National Museum; Dr. Walter Hough, curator for anthropology, and Dr. Paul Bartsch, curator for mollusks; Mr. Martin R. Speelman, of the Government Printing Office; Dr. L. O. Howard, of the Bureau of Entomology, and General George Richards, of the U. S. Marine Corps.

DR. WADE HAMPTON FROST, professor of epidemiology, has been appointed first dean of the School of Hygiene and Public Health of the Johns Hopkins University. Dr. Frost will assume his new position when the present director of the school, Dr. William H. Howell, retires on July 1. Under a new rule, adopted by the university in the creation of a deanship in place of a directorship, the administrative officer will be nominated by ballot of the advisory board of the school for appointment for three years. The dean thus appointed will be ineligible for nomination to succeed himself.

PROFESSOR J. GROVER BEARD, a member of the University of North Carolina faculty since his graduation in 1909, has been appointed dean of the University School of Pharmacy to succeed the late Dean Vernon Howell.

DR. ARISTIDES AGRAMONTE, professor in the medical faculty of the University of Havana, has accepted the post of professor of tropical medicine at the Louisiana State University.

DR. JOHN B. DEC. SAUNDERS, formerly of the University of Edinburgh, has been appointed assistant professor of anatomy in the School of Medicine of the University of California.

DR. RALPH B. KENNARD, formerly head of the physics department of Robert College, Istanbul, has been appointed a research associate of the Bureau of Standards, Washington, D. C., for research work in accordance with the provisions of the Luther B. McMillan Fellowship. The privilege of establishing this fellowship as a memorial to the late Luther B. McMillan was accorded the Johns-Manville Corporation by the director of the Bureau of Standards shortly after the death in August, 1929, of Mr. McMillan, consulting engineer for the company and a pioneer in research in heat transfer problems.

DR. N. B. GUERRANT, formerly associated with the Alabama Experiment Station, has accepted a position in the department of agricultural and biological chemistry at the Pennsylvania State College, where he will be in charge of the Vitamin Research Laboratory.

THE director of the Solar Physics Observatory of the University of Cambridge has, with the consent of the vice-chancellor, appointed Dr. R. O. Redman, of St. John's College, to be assistant director for five years from April 1 next.

WE learn from *Industrial and Engineering Chemistry* that following thirty-five years with the Dearborn Chemical Company, Chicago, officiating in various capacities, Mr. William A. Converse retired from active service on January 1, though retaining his interest in the company. Mr. Converse is the founder of the Willard Gibbs Medal.

DR. CHARLES L. PARSONS, of Washington, has been appointed business manager of the American Chemical Society, of which he has been secretary since 1907. Dr. Parsons is the first incumbent of this post, created by the board of directors as a development of the society's reorganization policy. Recently the number of directors was increased from ten to fourteen, Dr. Charles L. Reese, of E. I. du Pont de Nemours and Company, Wilmington, Delaware, having been made chairman of the board.

DR. CHARLES H. HALLIDAY, epidemiologist for the Maryland State Board of Health, has been appointed commissioner of public health for the Virgin Islands. Dr. Andrew Simpson, professor of engineering at Swarthmore College, has been appointed commissioner of public works.

DR. H. O. FORREST recently resigned as associate professor of chemical engineering and director of the Research Laboratory of Applied Chemistry at the Massachusetts Institute of Technology, to become a member of the staff of the M. W. Kellogg Company, Jersey City.

DR. CARL E. LADD, director of extension in the College of Agriculture of Cornell University, has been granted a year's leave of absence to become deputy commissioner of conservation for New York State. The appointment was made by Henry Morgenthau, Jr., who became commissioner under appointment of Governor Roosevelt on January 1. For the past few months, Dr. Ladd has been working on the organization of a program of economic extension work for the U. S. Department of Agriculture.

DR. BANCROFT GHERARDI, vice-president and chief engineer of the American Telephone and Telegraph Company, has been elected to the presidency of the American Standards Association. He will assume the direction of the standardization activities of the organization, a task in which more than 2,000 representatives of about 500 national trade, technical and governmental groups are engaged.

DR. F. A. VARRELMAN, head of the department of biology of the American University, has been granted a leave of absence for the second semester to complete research at the New York Botanical Garden.

PROFESSOR LOUIS KAHLENBERG, president of the Electrochemical Society, recently lectured to the chem-

ists of New York and vicinity at the Chemists Club on the subject "The Electrometer in Chemistry." He also addressed the Chemists at Philadelphia on "The Separation of Crystalloids from one another by Dialysis." On the trip east, Dr. Kahlenberg installed a new section of the Electrochemical Society at Cleveland, and visited the local sections of the society at Pittsburgh and Niagara Falls. In March he will address the sections at Detroit and Chicago.

DR. S. A. MITCHELL, director of the Leander McCormick Observatory, University of Virginia, will give the second Stuart McGuire Lecture at the Medical College of Virginia, Richmond, on March 25. His subject will be "Eclipse Hunting in the South Seas." The Stuart McGuire Lecture was established a year ago in recognition of the services of Dr. Stuart McGuire to the college, to medical education and to surgery.

DR. ROY CHAPMAN ANDREWS, leader of the Central Asiatic Expeditions and vice-director of the American Museum of Natural History, New York City, will give a lecture at the museum on March 11 on "Exploration in the Gobi Desert."

DR. GEORGE F. KAY, head of the department of geology of the State University of Iowa, and state geologist of Iowa, lectured recently at Smith College and Columbia University. His subject was "The Pleistocene of Iowa."

DR. R. W. HEGNER, director of the department of protozoology at the Johns Hopkins University, gave lectures before the Iowa State College on February 23 and 24. He was also the speaker at a dinner of the society of Sigma Xi during his stay in Ames.

MR. HENRY I. HARRIMAN delivered the third Aldred Lecture at the Massachusetts Institute of Technology on February 27. He spoke on "The Meaning of the Major Business Trends of the Day." Mr. Harriman is chairman of the New England Power Company. Mr. Othmar H. Ammann gave an illustrated lecture on "Recent Progress in the Construction of Large Bridges" on March 6. Mr. Ammann is chief engineer of the Port of New York Authority and is in charge of construction of the new suspension bridge across the Hudson River.

AT a luncheon on February 28 given by the American Institute of the City of New York, the speakers were Dr. A. F. Blakeslee, assistant director of the Carnegie Station for Experimental Evolution of the Carnegie Institution, whose subject was "Biological Effects of X-Ray"; Harold G. Petsing, educational director of the Westinghouse X-Ray Company, who spoke on "New Uses of X-Ray in Industry"; Dr. William H. Meyers, director of the Roentgenological Department of the New York Post-Graduate Medical School and Hospital, whose subject was "X-Ray—Diagnostic and Therapeutic Uses."

PROFESSOR FRANZ VON GROER, director of the department of pediatrics of the University of Lemberg, Poland, is a visiting professor at the University of Illinois College of Medicine, Chicago, under the Theodore B. Sachs Memorial Fellowship. This fellowship was established through a grant from the Chicago Tuberculosis Institute. Following his work in Chicago, Professor von Groer will hold clinics and lectures at the University of Michigan, the University of Cincinnati, Western Reserve University, Cleveland, and the University of Iowa. He will then make a tour of the west, where he will lecture at the University of Colorado, the Los Angeles Academy of Medicine, the San Francisco Academy of Medicine, the Portland Academy of Medicine and the Seattle and Spokane Medical Societies.

THREE free public lectures on muscular work and fatigue, arranged by the National Institute of Industrial Psychology, under the Heath Clark Bequest, have been delivered by Dr. G. P. Crowden at the London School of Economics and Political Science.

THE Jubilee Celebration of the Society of Chemical Industry will take place in London next July under the presidency of Sir Harry McGowan.

THE International Congress of Wood Industry and Forestry will convene in Paris from July 1 to 4. It will be followed during the following week by an excursion through the Alps to the French Riviera.

Nature reports that the Faraday Society has arranged a general discussion on "Photochemical Processes" to be held in the chemistry department of the University of Liverpool on April 17 and 18. Chemists and physicists from the United States and the Continent have been invited to attend the conference and to send contributions. There will be four sessions, each with an introductory paper, which, like all the contributions, will be distributed previously, and taken as read. The four subjects are: "Molecular Spectra in Relation to Photochemical Change," "Photochemical Kinetics in Gaseous Systems," "Photochemical Change in Liquid and Solid Solutions," and "Photosynthesis." The introductory papers, respectively, are by Professor R. Mecke, Professor M. Bodenstein, Professor Berthoud and Professor E. C. C. Baly.

THE benefits of what has proved to be the most effective known fumigant for certain foodstuffs stored in quantity have just been given to the government and people of the United States by two investigators of the U. S. Department of Agriculture, Dr. Ruric C.

Roark, a chemist of the Bureau of Chemistry and Soils, and Dr. Richard T. Cotton, an entomologist of the Bureau of Entomology. This month they obtained a patent on ethylene oxide as a fumigant and insecticide, the value of which was first proved by them in April, 1927. Drs. Roark and Cotton applied for their patent just in time to secure the free use of ethylene oxide for the American public. A well-known German dye company, recognizing the great commercial possibilities of ethylene oxide, had already applied for a United States patent in addition to the German patent under which this gas is used abroad. Following a hearing before the examiner of interferences of the U. S. Patent Office, the prior claim of Drs. Roark and Cotton was recognized and the public service patent was granted to them on February 3.

THE fifth season of the Allegany School of Natural History, conducted by the Buffalo Museum of Science, in cooperation with the New York State Museum, and in affiliation with the University of Buffalo, in Allegany State Park in Western New York, close to the Pennsylvania border, will be held from July 8 to August 27. Courses will be given in field zoology, field geology, field botany, natural history of birds, and nature study. The faculty is composed of Dr. R. E. Coker, Director, Ph.D. (Johns Hopkins); Aretas A. Saunders, Ph.B. (Yale); Professor William P. Alexander, B.Sc. (Cornell), and L. E. Hicks (the Ohio State University). An instructor in field geology will be named later.

THE sixteenth annual meeting of the American Association of Petroleum Geologists will be held on March 19, 20 and 21, at San Antonio, Texas, with the Gunter Hotel as convention headquarters. The San Antonio Geological Society, which is an official section of the national association, is the host and will provide local entertainment besides field trips to the Balcones and Mexia fault lines, to Laredo and into Mexico. The national officers of the association, which now has 2,550 members, are: *President,* Sidney Powers, chief geologist for the Amerada Petroleum Corporation, Tulsa, Oklahoma; *past-president,* J. Y. Snyder, operator, Shreveport, Louisiana; *first vice-president,* R. D. Reed, chief geologist for The Texas Company of California, Los Angeles; *second vice-president,* Marvin Lee, consulting geologist, Wichita, Kansas; and *third vice-president,* Frederic H. Lahee, chief geologist for the Sun Oil Company, Dallas, Texas. The officers of the San Antonio Section are: *president,* D. R. Semmes, consulting geologist; *past-president,* Chas. H. Row, of the Sun Oil Company; *vice-president,* H. H. Cooper, consultant; *secretary-treasurer,* Ed. W. Owen, of L. H. Wentz Oil Division; and *member executive committee,* J. M. Dawson, of the Gulf Production Company. Concurrent meetings to be held with the geologists are those of the Society of Economic Paleontologists and Mineralogists and the Society of Petroleum Geophysicists.

DR. THOMAS S. BAKER, president of the Carnegie Institute of Technology, has returned after two months' travel in Europe in the interest of the third International Coal Conference which will be held at the Carnegie Institute of Technology in November. The last conference was held in 1928. Members of the advisory board of the conference include: James A. Farrell, John Hays Hammond, Samuel Insull, Frank B. Jewett, A. W. Mellon, F. A. Merrick, Auguste G. Pratt, H. B. Rust, Matthew S. Sloan, Gerard Swope and Walter C. Teagle. The program will include papers on the carbonization, liquefaction and gasification of coal; by-products; the mechanism of combustion; cleaning of coal and its preparation for the market; pulverized fuel; power plants; domestic heating, etc.

CAPTAIN DONALD B. MACMILLAN expects to sail on June 20 from Wiscasset, Maine, on his fourth expedition to the Arctic regions. He will be accompanied by a large staff of scientific men and will be followed by Sir Wilfred Grenfell, of London, who lived many years in Labrador, and Dr. Alexander Forbes, of the Harvard Medical School. Headquarters of the expedition will be established in Captain MacMillan's scientific station near Nain in Iceland. Three airplanes will be included in the equipment. One of the principal objectives is the study of glaciers to determine the possibility of the formation of another glacier age. Glaciers in other parts of the world are diminishing, but those in the far north are increasing. It would take thousands of years, however, to affect seriously the temperatures in the United States. At Nain, Labrador, a permanent base will be established. From there Commander MacMillan plans to fly inland in a cabin monoplane, capable of taking off and landing on ice caps. The expedition will be in touch by radio with New York and Chicago at all times.

THE third Marshall Field Archeological Expedition to British Honduras and Guatemala to conduct excavations on ancient Maya sites and ethnological research among the modern Mayas, sailed from New Orleans on February 20. Dr. J. Eric Thompson, assistant curator of Central and South American archeology, who led the two previous expeditions in 1928–29 and 1929–30, will again lead the expedition. The present expedition has a wider scope of operations than the earlier ones, and will remain in the field probably for a period of six or seven months. After landing at Belize, the expedition will proceed by boat up the coast to the mouth of the New River, and thence inland to the head of navigation. Thence by mule pack train and on foot the journey will con-

tinue to the site of the ancient city of Kax Uinic, which is situated on the frontier between British Honduras and Guatemala. There, with a party of Maya diggers, certain ruins will be excavated.

THE advancement of research in experimental and theoretical physics at the University of Bristol is assured by a gift of £50,000 by the Rockefeller Foundation and an offer of £25,000 by Mr. W. Melville Wills, of Bristol, to meet the stipulation of the Rockefeller Foundation. The gift is the climax of negotiations which have been going on for some time, during which representatives of the foundation have visited Bristol several times to make investigations as to the work of the Henry Herbert Wills Physics Laboratory. These convinced them that it was worthy of such liberal encouragement. Under the direction of Professor A. M. Tyndall it has won a wide reputation in the few years it has been open. It was founded by a gift of £200,000 by Henry Herbert Wills. Its founder in all gave over £680,000 to the university.

A CORRESPONDENT of the *Journal* of the American Medical Association reports that the institute for heart research established in Bad Nauheim, through a gift of Mrs. Louise G. Kerckhoff, of Los Angeles, is nearing completion and can probably be opened the coming spring. The new institute, named after the donor of the "Kerckhoff-Institut," will be in charge of Professor Groedel of Bad Nauheim. There will be four departments: a department of examination and diagnosis for patients of the social insurance system; a department for the collection of statistics on the causes of heart disease; a department for public enlightenment as to the causes and the best methods of combatting heart disease, and a department for experimental pathology and therapy of heart disease. An administrative council composed of federal representatives, the chairman of the bureau of insurance of Hesse, and representatives of neighboring universities and members of the medical profession will manage the institute.

ON February 3 the Congregation of the University of Oxford passed a decree accepting the offer of the Forestry Commission and the Secretary of State for the Colonies to make contributions at the rate of £5,000 a year as from March, 1929, to July, 1931, to the maintenance of an Imperial Forestry Institute in Oxford, the university undertaking to make during the same period contributions to the Department of Forestry at a rate not exceeding £300 a year in addition to its current contribution. Mr. C. G. Morison, in proposing the decree, explained that it is a renewal of a former decree. The institute, which has now been in existence for about five years, is active in research and in giving post-graduate instruction. The relations between the institute and the university are at present engaging the attention of council.

THE possibility of establishing an insecticidal plant industry in the Virgin Islands to supply this country with important insecticidal materials, which are now imported at high cost from foreign countries, will be investigated by Dr. W. W. Skinner, assistant chief of the Chemical and Technological Research Unit of the Bureau of Chemistry and Soils, U. S. Department of Agriculture, who left Washington for the islands on February 26. Dr. Skinner goes to the Virgin Islands at the request of the Department of the Interior which recently was placed in charge of the islands and which is seeking to rehabilitate the agriculture by the introduction of new industries to take the place of the production of oil of bay and sugar. These were formerly the leading native industries but have recently been suffering from the world depression and the over-production of sugar. Dr. Skinner will investigate the possibility of aiding the islanders to rehabilitate the bay-rum industry by assistance of a chemical character; he will study the situation with regard to the production of sugar; and particularly he will investigate the possibilities of growing such insecticidal plants as pyrethrum, derris, and "cube," and the extraction from these plants of valuable insecticidal materials. He will also consider the advisability of establishing a chemical laboratory to aid such developments in the islands.

DISCUSSION

ISOLATION OF PROTEIN CRYSTALS POSSESSING TRYPTIC ACTIVITY

A CRYSTALLINE protein has been isolated from commercial preparations of "trypsin" which digests casein and gelatin in neutral solution. The digestive power of the crystals is about ten times that of the most active commercial preparations and the activity remains constant through three successive crystallizations. The substance, however, is exceedingly unstable and unless care is taken it becomes less active during the course of the preparation. It is obtained by extraction of the crude preparation with one quarter saturated ammonium sulfate. The extract is brought to one half saturated ammonium sulfate and filtered. The filtrate is saturated with ammonium sulfate and the resulting precipitate filtered off and redissolved in cold one quarter saturated ammonium sulfate. Saturated ammonium sulfate is added slowly with stirring to faint turbidity and the solution is brought slowly to 25° C. Small square platelets which tend to form

chains or clumps appear in the course of about an hour and crystallization is complete in two or three hours.

JOHN H. NORTHROP
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LABORATORIES OF THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH,
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FEBRUARY 8, 1931

YELLOW-SPOT DISEASE OF PINEAPPLES TRANSMITTED BY THRIPS TABACI LIND.

EXPERIMENTAL evidence has been obtained by the writer that an insect identified as *Thrips tabaci* Lindeman is a major vector operating in the field occurrence of a destructive disease of pineapple plants in the Hawaiian Islands, and furthermore, that this insect carries the virus to pineapple from certain weeds of which *Emilia flammea* Cassini now appears most important. Hitherto no means of transmission of this disease has been known. This preliminary note summarizes the evidence which will be published in detail in the near future.

The yellow-spot disease of pineapples is an infectious chlorosis with some distinctive and striking characteristics. In many respects it resembles diseases of both mosaic and ring-spot types, while in others it stands alone. Symptoms begin with a distinct "initial spot" with which thrips egg-punctures and feeding injury are generally associated. This spot, of about 5 to 20 mm diameter, is characteristically circular or rounded in outline, chlorotic and somewhat hypertrophied. Often it is concentrically banded dark and light. Extending down the leaf from this initial spot and developing on the younger leaves of the plant are chlorotic stripes and circular spots, sometimes strikingly zonate. Occasionally a coarse mosaic pattern develops in plants that have been long diseased. Pronounced dwarfing occurs as in many virus diseases. In this case the dwarfing is commonly unilateral, and leads to a marked curvature of the plant. Necrosis and rotting of affected parts follow, leading to death and decay of the plant within a few weeks. Microorganisms, apparently wholly secondary, are involved in this breakdown, although none have been detected in earlier stages.

Closely associated with yellow-spot in its field occurrence is a virus disease of *Emilia flammea* which likewise shows both ring-spot and mosaic characteristics. Thrips (*T. tabaci*) collected from this diseased weed in the field and allowed to feed upon healthy pineapple and Emilia seedlings have transmitted the virus, producing yellow-spot in pineapple and ring-spot mosaic in Emilia. Furthermore, thrips reared through several generations in the greenhouse on diseased Emilia plants have similarly proved infective.

For critical experimental testing, pedigreed non-viruliferous colonies of this thrips were established. These colonies were started from a single larva each, which was removed to an insect-free seedling of Emilia or of *Pisum sativum* L. at the moment of hatching and before feeding had begun. Thrips from such colonies, when tested on both Emilia and pineapple seedlings, have proved non-infective. When, however, these non-viruliferous thrips have been allowed to feed on diseased Emilia plants they have acquired the virus which they have later transmitted to both Emilia and pineapple, producing typical symptoms in a high percentage of plants.

Preliminary evidence indicates that certain plants in addition to Emilia may be sources of the yellow-spot virus, but it appears that this one plant, because of its abundance in pineapple fields and because of its suitability for the rapid reproduction of thrips during certain seasons, is now of major importance. The feeding of this insect upon pineapple plants appears to be quite incidental, and therefore it is probable that any natural transfer of the virus from pineapple to pineapple is relatively uncommon.

This is not the first well-established case of virus transfer by one of the Thysanoptera. Pittman[1] (see also the report by Dickson[2]) has already demonstrated a thrips (*Frankliniella insularis*) to be the vector of spotted wilt of tomatoes in Australia.

MAURICE B. LINFORD

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FRACTURING AND MOVEMENT IN ROCKS WITHOUT APPARENT DISPLACEMENT[1]

A RATHER unusual kind of rock deformation has been found along one of the branches of Bluff Creek in the southeastern part of the Nortonville quadrangle about thirteen miles northeast of Hopkinsville, Kentucky. The rocks at this locality exhibit typical features of faulting but show no dislocation of the beds. They are abundantly grooved and slickensided, showing the effects of movement under compressive force, but bedding planes can be traced across the breaks with none or at the most not more than one or two inches of dislocation. All the features of faulting are the results of components of vertical movement. Careful examination has failed to reveal any trace of either oblique or horizontal movement parallel to the

[1] H. A. Pittman, "Spotted Wilt of Tomatoes," *Jour. Council Sci. and Industrial Res.* (Australia), 1(2): 74–77, 1927.

[2] B. T. Dickson, "Spotted Wilt of Tomatoes," in "The Work of the Division of Economic Botany for the Year 1928–29," *Council Sci. and Industrial Res.* (Australia) *Pamphlet*, 14: 18–19, 1929.

[1] Published with the permission of the director of the Kentucky Geological Survey.

fracture surfaces. The area of deformation is located in a region where faulting is rather common so that the fracturing is not out of the ordinary. The unusual feature, however, is the absence now of any displacement along the lines of fracture.

The formations involved in the deformation are the Glen Dean limestone and Tar Springs sandstone of the Chester series of Mississippian age. The general dip of the rocks in the surrounding territory is about one degree in a northward direction. The Glen Dean limestone dips under about one fourth mile down stream from this locality. In the area of disturbance the rocks are folded into a small anticline, the trend of whose axis is at right angles to the general dip direction. The amount of elevation in the fold is small, approximately twenty feet, being sufficient to bring the Glen Dean limestone again to the surface in the bed of the creek. The fold is asymmetrical with the steeper dip, about three or four degrees, on the south and a lesser dip, about two degrees, on the north flank. The zone of deformation is parallel to the axis of the fold and is on the steeper, southern flank.

In the zone of deformation, which is about twenty feet in width, the Tar Springs sandstone has been fractured along a number of surfaces which have dips ranging from seventy degrees to vertical. Some are inclined toward the south and others toward the north, but the strike of all of them is essentially parallel to the axis of the fold. Some of the inclined breaks intersect and even at the points of intersection there is no offsetting of the breaks or of the beds. Some of the breaks are closely spaced, two to four inches apart, while others are several feet apart. Almost all of them exhibit effects of movement, the fracture surfaces being grooved and polished. The walls of many of the surfaces of movement are not now in contact, some of the breaks being open as much as an inch. How much movement there may have been along these lines of fracture it is impossible to say.

The following explanation is offered for the phenomenon. At the time of folding of the rocks the south flank of the anticline broke along this zone, the pressure being sufficient to cause enough movement to polish and groove the sandstone. With a decrease in the folding pressure the dislocated beds moved back to their original positions so that, while the effects of pressure and movement are clearly preserved, the beds show no dislocation or at the most only a very little. An alternate hypothesis is that the beds may have been in movement up and down along the fracture surfaces several times during the period of deformation. Due to the weight of overlying sediments and the inherent elasticity of the folded rocks, they tended to return to a more flattened attitude during such times as the deformative force was diminished. After deformation, the diminished compressive force allowed the beds to return to the relative positions they occupied before breaking. Although oscillatory movements along faults and partial returns to the original positions are known to have occurred, the writer knows of no other instance where the amount of recovery has so nearly equalled the amount of deformation.

A. H. SUTTON

UNIVERSITY OF ILLINOIS

AN UNUSUAL RAINBOW

A REMARKABLY brilliant rainbow appeared to the northeast of Tucson, after a hard shower about 4 P. M. on February 13, 1931. This rainbow was out of the ordinary in that a repetition of the spectrum showing first, second, and third order colors in the same sequence occurred on the inside of the rainbow, as well as a fainter secondary reversed rainbow about 10 or 15 degrees outside of the primary arc. The brilliance of the rays of the sun in our southwest is no doubt responsible for the observance of this unusual phenomenon.

ROBT. E. S. HEINEMAN,
Assistant Geologist

UNIVERSITY OF ARIZONA

SCIENTIFIC BOOKS

Thomas Say, Early American Naturalist. By HARRY B. WEISS and GRACE M. ZIEGLER. Foreword by L. O. Howard. Springfield, Illinois, Chas. C. Thomas. 260 pp.

SAY died in 1834, so that nearly a hundred years have been allowed to pass before the publication of a really satisfactory biography. Every zoologist and more particularly every entomologist and conchologist, has been familiar with the name of Say, with a more or less vague understanding that he was one of the founders of the science in America. The eccentric naturalist, in Fenimore Cooper's "Prairie," illustrates the once prevalent attitude toward the zoological explorer. The present book describes Say's life in the environment of his time and we may well marvel at his steadfast zeal, his ability in overcoming obstacles, the excellence and volume of his work. Aided by his friend and patron, William Maclure, he managed to accumulate a good library of zoological works, especially those in which American animals were described

by European authors. He corresponded with zoologists on both sides of the Atlantic and made every possible effort to avoid the publication of synonyms. He visited Colorado with Long's Expedition, and also carried on explorations in the northwest, as a member of the expedition of 1823 to "the source of St. Peter's River, Lake Winnepeek, Lake of the Woods, etc., etc." With Maclure he traveled to Florida (1817–18) and Mexico (1828). As the result of all these activities he was enabled to describe considerably over a thousand new species of American beetles, over four hundred insects of other orders, a large proportion of our common shells, as well as crustaceans, birds, mammals, reptiles and a certain number of fossils. His work has stood the test of time, and his species are for the most part currently recognized. Mrs. Say, who survived until 1886, drew the figures on sixty-six plates to illustrate Say's Conchology, and the figures were colored by hand with the aid of some pupils.

When Robert Owen established his socialistic community at New Harmony, Indiana, Maclure was drawn into the undertaking, believing that he could make the place the center and fount of American education. Say accordingly left Philadelphia and became a resident of New Harmony. We are told how disputes arose and the experiment ended in failure, as perhaps ought to have been foreseen from the beginning. But Owen's sons remained to do distinguished work in America and in a large sense the idealism of the movement was not wasted, but has continued to bear fruit down to the present time. Even the lessons derived from its failure have been valuable.

Say's shells are for the most part in the Academy of Natural Sciences at Philadelphia, but of his insects it seems they have only one specimen, the type of the famous White Mountain butterfly. The insects were destroyed by dermestids, and although it is not so stated, must have been thrown away after Dr. T. W. Harris returned the ruined collection to the Academy. It was not understood at the time that even the fragments would have been of great value to posterity. Fortunately the species were so well described that there is usually little dispute concerning their identity. It was however a defect in Say's work that he was accustomed to cite localities very vaguely. The book represents a very large amount of work and is full of interest. Every student of American zoology should read it, and then Dall's "Life of Baird," and thus learn how the science was developed in this country during the nineteenth century. It is a story of enthusiastic workers overcoming difficulties which seem terrific to us in these relatively easy days. When we are inclined to complain of the obstacles in our way, it is good discipline to turn to the life of such a man as Say, and see how he conquered what seemed to be the iron hand of fate.

T. D. A. COCKERELL

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

A NEW SINGING TUBE

LAST April, while making a piece of apparatus from pyrex capillary tubing, I noticed that a piece about 10 cm long and 2 mm inside diameter began to emit a musical note when the bulb which I was blowing on the end reached a volume of approximately 2 cubic centimeters. Recalling that Dr. C. T. Knipp, of the

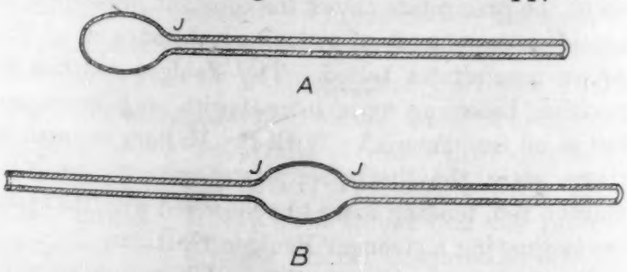

FIG. 1

University of Illinois, had developed a singing tube some ten years ago, I assumed this to be what he had observed.

On running across an account[1] of Professor Knipp's tubes recently, however, I think the difference in the two cases is worthy of notice. His tubes as reported were all substantially of the form of an ordinary mercury trap.[2] It appears that this special form is not necessary: a tube with a bulb on one end and the other end open (*A*, Fig. 1), or with the bulb in the middle and both ends open (*B*, Fig. 1) will sing, with various shapes of bulb. The note emitted appears to depend chiefly on the volume of the bulb and tube, the temperature at the junction (*J*) of bulb with tube, and the diameter of the tube.

The phenomenon has been observed with tubes of various lengths and from 1½ to 4 mm inside diameter; but outside these limits it has not been detected. When the junction of the bulb with the tube is heated to about the temperature of redness the oscillations begin. Heating elsewhere is not effective until this temperature is attained at the junction.

A tube 13 cm long, 2.3 mm inside diameter and having a bulb of 1.8 cubic centimeters (approxi-

[1] *Phys. Rev.*, xii, December, 1918, p. 191.

[2] SCIENCE, April 22, 1921, p. 393.

mately) emits middle C. As the temperature at the junction is increased the pitch is raised; but it has not been determined whether this is due to the temperature alone or to the gradual shrinking of the bulb, as the temperatures required are above that at which pyrex softens. To avoid this difficulty, it is planned to continue the investigation using tubes of quartz.

F. L. ROBESON

VIRGINIA POLYTECHNIC INSTITUTE

A SIMPLE MICROSCOPE EYEPIECE POINTER

THE use of an eyepiece pointer to augment the value of a demonstration under the microscope is usually appreciated by both student and instructor in the laboratory. The customary procedure of gluing a short hair to the rim of the ocular diaphragm is simple and effective. When, however, the eyepiece is in demand both with and without a pointer, the necessity of having to adjust the hair each time is highly inconvenient.

To meet the need for a pointer that could be readily inserted and removed from the ocular, the writer has devised the accessory here described.

A round 18-mm coverglass, free from imperfections, is selected and cleaned with acid alcohol. This forms a base upon which a pointer may be mounted. The pointer itself is drawn from a thin glass rod to a fiber-like thickness. With a little care and practice the glass can be drawn to a diameter appreciably less than that of even a fine human hair.

The tapered end of the pointer is then placed on the base, a drop of Canada balsam added followed by a second coverglass, likewise perfectly clean. By means of the protruding end of the pointer its tip may be centered and its axis adjusted parallel to the radius of the two coverglasses. In this way the fine rod is sealed, free from disturbance between the two coverglasses. After the protruding end of the pointer is snapped off the finished product results.

If actually embedded in the balsam the glass pointer appears highly refractory when viewed through the microscope. If this is objectionable, the pointer can be held in place by applying the cement only to the edges of the coverglasses. When so mounted it is seen as a black line.

A dozen or so of these pointers can be made and mounted in half an hour and they may then be kept permanently on hand for instant use when needed.

JAMES A. LOUNSBURY

DEPARTMENT OF BOTANY,
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SPECIAL ARTICLES

OBSERVATIONS CONCERNING THE CAUSATIVE AGENT OF A CHICKEN TUMOR[1]

IN early publications on the chicken tumor group, some of the properties of the filterable agents causing these neoplasms were described. Recently additional observations have been reported from this laboratory which may be summarized as follows: The agent of Chicken Tumor I, a spindle-cell sarcoma, is selectively adsorbed and fixed by certain mesodermal tissues from susceptible animals, but not by similar tissues from non-susceptible animals. The plotted curve of the amount of ultraviolet light of selected wave lengths required to inactivate the tumor agent shows a significant qualitative and quantitative variation from the curves for bacteria, typical viruses and bacteriophage. The tumor producing activity of the tumor filtrates can be precipitated out with a protein fraction and somewhat purified.

Certain extensions of the work will now be recorded.

Steps in Purification of the Tumor Agent

Precipitation. As already reported, the agent active in a tumor filtrate can be precipitated out by electrodialysis or by increasing the hydrogen-ion concentration with acid or buffer. The pH at which the precipitate comes down is between 4.4 and 4.8. It carries all of the agent with it and can be dissolved in alkali and reprecipitated repeatedly without destruction of the agent.

The average amount of nitrogen in the precipitate is about 12 per cent. and varies little with the method of preparation of the extract. The phosphorus ranges from 0.16 per cent. to 0.69 per cent., being lower when the extract is prepared with water and higher when an alkali or Ringer's solution extract is used. Hydrolysis of the precipitate shows the constant presence of a considerable amount of reducing substance in all the active precipitates tested. The Feulgen reaction is positive, becoming more intense with each reprecipitation of the material. With the Mallory connective tissue stain the first precipitates give generally a maroon red, tending more to yellow red with the specimens showing a stronger Feulgen reaction.

Purification by Adsorption. Adsorption on colloidal aluminum hydroxide, a method already employed by other investigators, was utilized in attempts to purify the agent. The results were disappointing in that so little of the agent could be released after adsorption that inoculation produced at best tumors much smaller and less vigorous in their growth

[1] From the laboratories of the Rockefeller Institute for Medical Research.

than those resulting from injections of comparable amounts of the original extracts. The point of importance which developed from this study was that, after centrifuging out the aluminum hydroxide with its adsorbed materials, the supernatant fluids proved to be far more active than the full strength extracts. In fact, it is the most active material so far obtained, and this in spite of the fact that an appreciable quantity of the agent is taken down with the aluminum hydroxide.

When there has been a proper ratio of aluminum hydroxide (Willstätter Type C) to tumor extract, the supernatant fluid just mentioned is viscous, generally opalescent but often water clear. No precipitate is produced by acetic, tungstic, tannic or chloracetic acids. It gives negative Biuret, Millon and Xanthoproteic tests and only a slightly positive Ninhydrin reaction. Analysis shows an average nitrogen content of 0.050 mg per cc and a reducing substance figured as glucose of 0.175 mg per cc. The form in which the nitrogen occurs in this fluid is as yet undetermined, but the failure to induce sensitization in guinea pigs by the injection of large amounts suggests that it is either non-protein in nature or is a protein lacking antigenic properties.

Evidence exists that the viscosity of the supernatant fluids is due to the presence of a substance resembling chondroitin sulphuric acid. An attempt has been made to remove this substance by combining it with a basic protein. When the latter is precipitated out it takes with it all of the viscous material, leaving a water-clear, limpid fluid, which retains a tumor producing activity at least equal to that of the original supernatant fluid before removal of the viscous material, and far more so than the original concentrate. Chemical study of it is not yet complete.

Antigenic Properties of the Tumor Agent

The literature on the antigenic properties of the tumor producing agents will not be reviewed, since our study is concerned only in relation to the steps in the purification of the active principle. By the injection into rabbits of a concentrated Berkfeld filtrate of a water extract of the chicken tumor a good precipitating serum was obtained, which proved capable of neutralizing the tumor producing activity of a tumor extract. It was then found that the protein fraction of such a tumor filtrate, prepared as already described, was also effective in calling out precipitating and neutralizing antibodies in rabbits. A Berkfeld filtrate of an extract of tumor in Ringer's solution induced the formation of precipitins and neutralizing bodies, but the active protein fraction of this Ringer's extract failed to induce definite precipitins, though the neutralizing power of this serum was as good as that of the other sera. That the neutralizing power of these various sera was not referable to ordinary anti-chicken protein antibodies was shown by the failure of a strong anti-chicken serum of the rabbit to neutralize the activity of the tumor agent.[1]

After the development of the method of preparing highly active tumor extracts practically free of protein, the antigenic properties of such material were tested, the full strength concentrate being employed as control material. The sera of the rabbits injected with this latter contained precipitins and complement fixing antibodies, and they neutralize active tumor filtrates. The sera from rabbits immunized with the purified material showed no precipitins, no complement fixing antibodies, gave negative Ramon flocculation tests, but were more strongly neutralizing to the active tumor extracts then the sera developed against the full extract. The interpretation of this result must await further study.

Evidence of an Inhibiting Principle in the Chicken Tumor

The occasional occurrence of an inactive tumor filtrate or extract of dry tumor material has been noted by a number of workers. Several such inactive preparations were encountered in the course of our study of the acid precipitates. It was noted in these cases that the protein fraction gave a negative or faintly positive Feulgen reaction, and showed an excess of blue colored material with the Mallory stain. This observation suggested the possibility that the inactivity of an extract might be due to the presence of an inhibiting substance. An experiment was undertaken to test the possibility that this inhibitor might be more soluble than the active material. The dry powder of the chicken tumor was thoroughly extracted with water, centrifuged and the sediment extracted a second time with water. The second extract proved more active in the production of tumors than the first. The sediment of the second extract treated a third time with water yielded an extract even more active than the second. The result might mean simply that the active material was difficultly soluble, more of it going into solution after the long treatment with water. That this is not the correct interpretation is indicated by the observation that the residue inoculated after the first extraction was less active than the residue after the second washing, and this in turn less active than the residue after the third washing. In fact the residue reached maximum activity only after being extracted four times with water. In this connection the finding should again be mentioned that the fluid left

[1] These studies were carried out with the assistance of Dr. D. C. Hoffman.

after the adsorption with aluminum hydroxide as above described is markedly more active in tumor production than the most concentrated filtrate, although some of the tumor producing material is carried down with the aluminum. No other explanation seems possible than that both tumor producing principle and some substance or condition inhibiting its activity existed in the fluid prior to adsorption with aluminum hydroxide, the process removing far more of the inhibitor than of the principle. While there is less activity in the aluminum supernatant fluid than in the original extract, yet, unhampered by the inhibitor, it is more active.

The details of the experiments and a discussion of the results will be published later.

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THE DEHYDROGENATION OF CHLOROPHYLL AND THE MECHANISM OF PHOTOSYNTHESIS

IN a recent paper,[1] it was shown that the allomerization of chlorophyll is essentially a dehydrogenation (oxidation) reaction. We have now been able to obtain additional evidence in favor of this view in a study of the dehydrogenation of the magnesium-free compound methyl phaeophorbide *a*. In a pyridine-acetone solution this compound is oxidized by potassium molybdicyanide; approximately two equivalents of reagent are required per mole. The product (methyl dehydrophaeophorbide *a*) yields the same hydrolysis products with hot alkali as allomerized phaeophorbide, and like this substance is not further oxidized by molybdicyanide. The difference between the spectra of methyl phaeophorbide *a* and methyl dehydrophaeophorbide *a* is slight in the visible range, but considerable in the near ultraviolet.

These facts, which prove that the chlorophyll molecule contains an easily dehydrogenated group, suggest at once a possible mechanism for photosynthesis. Emerson's recent work[2] has proved that chlorophyll is involved in the so-called Blackman dark reaction, and hence must be a participant in some strictly chemical step in the photochemical process. We suggest that this step is the reduction of carbon dioxide by chlorophyll itself, the other product being dehydrochlorophyll. In order to make the system chlorophyll-dehydrochlorophyll mobile, an enzyme would undoubtedly be necessary; this would account for the sensitivity of the Blackman reaction to hydrocyanic acid. The regeneration of chlorophyll would require energy furnished by the light. The steps can be represented thus:

Ch = chlorophyll
Ch(− 2H) = dehydrochlorophyll

(1) Dark reaction

$$12\ Ch + 6\ CO_2 + \text{enzyme} \rightarrow 12\ Ch(-2H) + \underset{\text{glucose}}{C_6H_{12}O_6} + 6\ H_2O$$

(2) Light reaction

$$12\ Ch(-2H) + \text{light} + 12\ H_2O \rightarrow 12\ Ch + 6\ O_2$$

This mechanism would appear to account for most of the facts now known about photosynthesis, including Warburg's experiments with a rotating sector. A calculation of the free energy of reduction of carbon dioxide (in the atmosphere) to glucose (in dilute solution) yields information in regard to the necessary reducing intensity of the chlorophyll-dehydrochlorophyll system if it is to function in reaction 1. A reducing intensity of 50 millivolts greater than the hydrogen electrode would be sufficient for reaction 1 to run very far towards completion. A reducing intensity equal to the hydrogen electrode would produce glucose in a thousandth molar solution, if the ratio of chlorophyll to dehydrochlorophyll were kept at about 100 to 1 in a steady state by a combination of reactions 1 and 2. Presumably the glucose or other primary reduction product of carbon dioxide is removed continually from the reaction by a series of irreversible processes. These calculations and a more detailed discussion will be published in full elsewhere.

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[1] Conant, Hyde, Moyer and Dietz, *J. Am. Chem. Soc.*, 53: 359, 1931.

[2] Robert Emerson, *Jour. Gen. Physiol.*, 12: 609, 623, 1929.

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